SOUTHERN RAILWAYS *Magazine*

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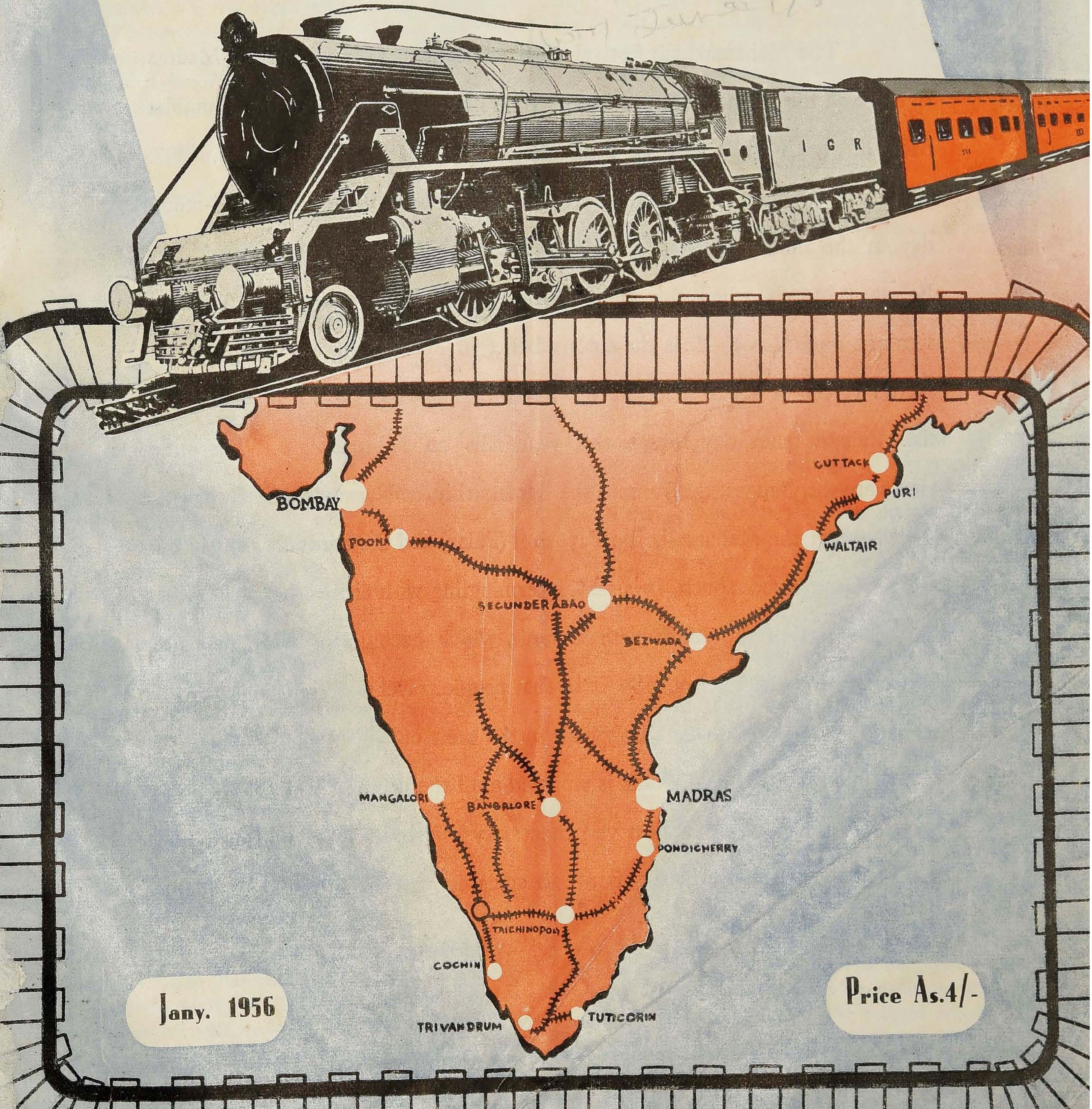

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The Great Mahamakham Festival at Kumbakonam

MAHAMAKHAM—BATHING DAY—25-2-1956

The Mahamakham festival at Kumbakonam (194 miles from Madras Egmore on the Madras-Dhanushkodi Main line) corresponds to the Kumbha Mela of North India and the Pushkaram festivals of the Andhra Desa. The celebrated Mahamakham festival occurs once in twelve years on the full-moon day in the month of Magha which synchronises with the English months of February-March, when the planet *Brihaspati* (Jupiter) passes the Zodiacal sign of *Simha* (Leo). It is the sincere belief of devout Hindus that the nine sacred rivers of India meet in the Mahamakham tank at Kumbakonam on the Mahamakham day which this year falls on February 25. The nine rivers are the Ganges, the Jumna, the Saraswathi, the Narmada, the Godavari, the Cauvery, the Mahanadi, the Payoshni (Palar) and the Sarayu. Thus, the sacred Ganges goes south, it is said, intermingling with eight other holy rivers in the waters of the Mahamakham tank, which becomes in consequence a centre of spiritual energy. So it is that people travel to Kumbakonam from all parts of India and have a holy bath in the tank on the Mahamakham day. Just before the festival, the tank is emptied until the depth of water is reduced to about 2½ feet, a precaution very necessary as thousands of persons enter the tank. The tank covers about 20 acres in extent and is one of the prettiest in South India.

The Influence of the Driving and Carrying Wheel Diameter on the Design, Performance and Behaviour of a Locomotive

By M. S. Surma

THE diameter, whether of driving or of carrying wheels is an important factor in the design of a locomotive. In the case of carrying wheels a large diameter (as nearly equal to that of driving wheel as possible) is always favoured, but in the case of driving wheels a compromise is necessary.

DRIVING WHEEL DIAMETER

Earlier locomotives were fitted with relatively large driving wheels. In the history of locomotive practice, driving wheels of as big a diameter as 9 ft. have appeared and this diameter is possibly a limit which has never been crossed. The reason for the adoption of such a large driving wheel in those days could apparently be :—

(i) To achieve higher train speed for given driving wheel R. P. M.

(ii) To have less wear and tear due to decreased rotational speed of the journal.

At a later stage certain investigators conducted experiments on the steam cycle efficiency and Professor Goss published the data collected by him in his book " Performance of Locomotives ". He states that whenever the speed of rotation of the driving wheels exceeds, what he terms as " critical speed ", a loss of efficiency occurs. This " critical speed ", he fixed, at 200 R. P. M. of the driving wheel.

In those days the locomotives were fitted with 'D' slide valves and Stephenson link motions. The cause of such a low " critical speed " was undoubtedly a low steam cycle efficiency, on account of wire drawing and bach pressure, both of which would still be greater if small driving wheels were fitted. If, therefore, at normal operational speeds, this " critical speed " was not to be exceeded to, the driving wheels had to be made very big.

As the time passed on, the need for drawing heavier loads grew more and more and boiler, on account of its relatively small size became a limiting factor in so far as an adequate steam supply to the cylinders was concerned. Necessity usually arose to employ double engines on stiff gradients, and some times in the wet weather, even to assist the engine to start with the train. To cope with this demand, the power of the engine and consequently the capacity of the boiler had to raised, but the presence of the large driving wheels brought in certain complications, such as,

(i) As the moving dimensions set a limit on the height of a locomotive, the diameter of the boiler could not be increased.

(ii) Any increased in the length of the boiler to raise its capacity meant the introduction of an additional axle in the wheel base.

(iii) If this additional axle was to be a carrying axle, the problem of adequate adhesive weight was to be faced and if it were to be a coupled axle, the question of length of the coupled wheel base would crop up.

The length of the coupled wheel base is one of the most important factors in the design of a locomotive, as it affects its stability to a very great extent. It is not in the scope of this short note to discuss fully its influence on the behaviour of a locomotive, but will be discussed to an extent of its relationship with the diameter of the driving wheel.

A locomotive consists of a number of trucks, main and auxiliaries. The main truck has all the coupled wheels grouped together in one frame, with all the axles parallel to each other, and is called coupled wheel base as well.

One fundamental thing in the design of a truck whether main or auxiliary (a truck consisting of carrying axles) is, that all the axles grouped together in one frame, should radiate from the centre of the curve, the loco negotiates. Any axle does not satisfy this condition affects the stability of the locomotive adversely.

It is, however, difficult to achieve this object absolutely, but the condition can be improved, if the coupled wheel base is reduced to a minimum possible length, by closer spacing of the coupled wheels. A reduction in the diameter of the driving wheel steel helps to achieve this object. It may be mentioned here

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(Inserted in the interests of Travelling Public by the Public Relations Officer, Southern Railways Magazine)

that it helps in efficient functioning of the end trucks controls, and reduces the friction moment at the coupled wheel treads.

In the modern days, on account of the introduction of improved valve gears, which are well known for their efficiency of steam distribution, the "critical speed", once fixed at 200 R. P. M. has shot up, in the case of,

(i) Walscheart gear to 300 R. P. M.

(ii) Cam operated gears to 360 R. P. M.

The introduction of these efficient gears has enabled the designer to employ comparatively smaller driving wheels, so necessary for the safe operation of high speed locomotives.

Another very important factor in the determination of the driving wheel diameter, is flange rail contact, a study of which reveals that there is a definite relationship between the wheel diameter, wheel base, angularity of the wheel with respect to rail and the slope of the wheel flange for safe operation. This can be verified geomatrically. As the slope of the flange at the gauge face is a fixed thing, a limitation is imposed on the wheel diameter in a particular wheel base.

A full discussion of this subject will be found in "NOTES ON WHEEL FLANGE PROFILE" by Mr. R. G. da Costa.

In the following paras, some merits and demerits of the smaller wheel are discussed briefly.

(i) From the following well known formula it is seen that tractive effort of a locomotive is increased with smaller wheel.

Tractive effort is equal to $\frac{P\ d^2\ S\ N}{2\ D}$

Where, P is MEP/ sq. in.

d is the cylinder diameter in inches.

S is the piston stroke in inches.

N is the number of cylinders.

D is the driving wheel diameter in inches.

(ii) The distance between the centre of gravity of the suspended masses and the coupled wheel centre line is increased which results in lower flange impacts on the rail.

(iii) As the spacing of the wheels can be closer, the length between the leading coupled wheel and the front truck centre is increased which improves guiding.

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(iv) The vertical distance between the coupled wheel centre and the bogie wheel centre is reduced (in the case of a bogie) reducing the swing of the bogie pivot pin.

(v) Comparatively lesser space is available for placing the counter balance weights and sometimes difficulty is felt even to balance the revolving masses, which results in " underbalancing " and is very injurious to the locomotive as well as track.

(vi) As the engine R.P.M. increases, for a given train speed, the unbalanced vertical component of radial force, which changes its direction very rapidly, becomes greater and gives a higher blow to the rail. All other things being the same, the " critical speed ", when the wheel is lifted clear off the rails, on account of this unbalanced force, whether due to " underbalancing " or " overbalancing ", is decreased. This will be clear from the following.

Let,

D be the driving wheel diameter, in ft.

W be the static wheel load, in lbs.

M be the balanced reciprocating or unbalanced revolving masses, in lbs.

b be the force due to gravity,

r be the crank radius in ft.

n be the number of driving wheel rev. /sec.

Now the single wheel hammerblow is given as,

$$\frac{M}{g}\,(2\,\Pi\,n)^2\,r \quad \ldots\ldots (1)$$

The wheel will be lifted clear off the rail

When,

$$\frac{M}{g}\,(2\,\Pi\,n)^2\,r = W \quad \ldots\ldots (2)$$

Circumference of the driving wheel = Π D Ft.

Let the " critical speed " be S ft./sec.

Number of the revolutions which the wheel will make to cover distance S = S/ΠD ....(3)

Substituting (3) for n in (1) we get,

$$\frac{M}{g}\,(2\,\Pi\,S/\Pi D)^2\,r = W \quad \ldots\ldots (4)$$

$$\frac{M}{g}\,r\,4\,S^2/D^2 = W$$

$$S = \sqrt{\frac{g\,D^2\,W}{4\,M\,r}} \quad \ldots\ldots (5)$$

But in these days, when the heavier locomotives with as light motion parts as possible, are used, it has been found that the locomotives are not very sensitive to the action of unbalanced reciprocating masses. Therefore the tendency is to balance a smaller percentage of the reciprocating masses. It has resulted in smaller hammer blow and higher " critical speed ".

(vii) The impulse of the blow transmitted to the rail, at low joints is higher. This has been dealt with on page 7.

If, therefore, higher train speed is desired, with due considerations for safety and efficiency of performance, the diameter of the driving wheel should be so proportioned as to get better results from the locomotive as a power unit and high speed vehicle.

CARRYING WHEEL DIAMETER

The carrying axles not only carry some of the weight of the locomotives but function as the guiding trucks as well, thus helping the locomotives in curving and reducing the intensity of the lateral forces through the control mechanism provided on them. If the diameter of these wheels is smaller than that of the driving wheels, the control mechanism will be away from the centre line of the driving wheels, which will result in inducing excessive " rolling ", when in action and the swing of the bogie pin—in the case of a bogie—will be greater. The designer, therefore, aims at making the carrying wheels as big as possible, within the constructional limits, so as to bring the control mechanism as near the plane of the coupled wheel centres as possible. It constrains the suspended masses to roll about an axis very near the coupled wheel centre line. The impulse at the hub of the driving wheel is, therefore, reduced.

Another advantage of the bigger carrying wheel is that the wave length of the sinous motion of the truck is increased. In the case of a single axle truck the length of the wave will be,

$$2\,\Pi\sqrt{\frac{D}{2}\times\frac{b}{t}} \quad \ldots\ldots (6)$$

and in case of double axle truck,

$$2\,\Pi\sqrt{\frac{D}{2}\times\frac{b}{t}} \times \sqrt{\frac{b^2\quad c^2}{b^2}} \quad \ldots\ldots (7)$$

Where,

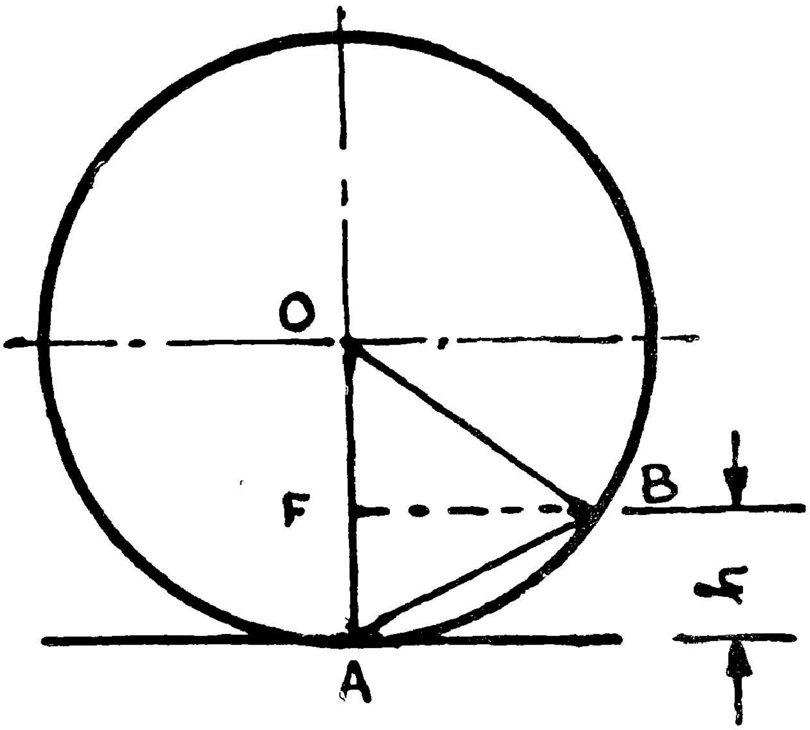
b is $\frac{1}{2}$ the track gauge at tread contacts,

c is $\frac{1}{2}$ the wheel base

t is coning of the tyre

GENERAL

The impulse of the blow which a wheel transmits to the rail, while passing over a low joint or any other vertical irregularity of track, is greater with a smaller wheel as will be seen from the following,



Let,

m be the unsprung mass of the wheel,

v be the speed at which it is travelling,

h be the height of obstruction on the road,

When running over a perfect track, the motion is at right angles to OA, but when the wheel is to encounter a low joint, the motion becomes at right angles to OB.

Now for the wheel to completely cross the obstruction, h, its periphey has to travel through the distance BA.

Let the time taken to travel this distance be, t,

Arc BA = chord BA = BF app.

In the triangle OBF,

$$BF = \sqrt{(OB)^2 - (OF)^2}$$

$$= \sqrt{(D/2)^2 - (D/2 - h)^2}$$

$$2 = \sqrt{Dh - h^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$t = \sqrt{\frac{Dh - h^2}{v}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

In crossing this obstruction the wheel rotates about the instantaneous centre B, and if the mass of the wheel, neglecting the weight of the axle box and the springs etc., is considered as concentrated at O, the centrifugal force will be,

$$\frac{2\,m\,v^2}{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

The impulse of the blow is equal to,
Force × the time for which it acts.

$$\text{i. e. } \frac{2\,m\,v^2\,t}{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Substituting (9) for t in (11) we get,

$$\frac{2\,m\,v^2}{D} \times \frac{\sqrt{Dh - h^2}}{v} = \frac{2mv\sqrt{Dh - h^2}}{D}$$

$$= 2\,m\,v\sqrt{\frac{Dh - h^2}{D2}}$$

$$= 2\,m\,v\sqrt{\frac{Dh}{D2} - \frac{h^2}{D^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

As h^2/D^2 is very small it can be neglected and the equation is reduced to,

$$2\,m\,v\sqrt{\frac{h}{D}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

CONCLUSIONS

It may be concluded from the foregoing, that the main factors which govern the determining of the diameter of the driving wheel are :—

(i) Driving wheel R. P. M. for a given operational speed and

(ii) Stability of the locomotive as a high speed vehicle.

As has been shown before that a smaller wheel contributes to the stability of a locomotive, its size should be so proportioned as not to affect the steam cycle efficiency adversely.

In India, where the maximum operational speed is not more than 65 miles/hour, and Walscheart valve gear with long travel piston valves is in use, the driving wheel R. P. M. of 5 can be allowed. This means that a driving wheel diameter of 5′-7″ is a good compromise.

The diameter of the auxiliary or the carrying truck wheels, for better results, may be as big as possible within the constructional limits.

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ELEMENTS OF WELDING METALLURGY

By P. K. V. Challam

METALLURGY is indeed such a vast subject, that it is impossible even to enunciate the broad principles within the scope of this article, but as an elementary knowledge of metallurgy is very essential to all classes of Welding Technicians, Supervisors etc., an attempt is made here to enumerate the salient features of the various metals which the welder is called upon to work with, either in the field of welding, cutting or other allied techniques and processes.

To attempt to apply certain welding and cutting or other allied processes to a given metal without sufficient knowledge of the characteristics of such a metal, is rightly described in certain quarters as attempting to cure a disease without diagnosing it. From this point of view the rather low degree of metallurgical knowledge present in the average welder of today is both inexcusable and deplorable. The sponsors of the welding industry are, therefore, right in laying stress on the basic education which they are endeavouring to impart to the welding personnel through Demonstration Shops and Welding Schools, where the beginner learns the subject in a proper way, and others belonging to a higher strata widen their existing knowledge to the advantage of themselves and the Welding industry in general.

Metallurgy has been defined as the art of working metals or the art of separating metals from the Ores, whereas Metalography may be defined as the study of the structure of metals. As Iron and steel from the major portion of the metals that present themselves to the welder, Ferrous Metallurgy has been dealt with in the following pages in wider detail than non-ferrous metallurgy.

Before proceeding further with this subject, it is thought advisable to enter a brief description of the production of iron and steel. The scope of this article does not, however, allow more than a general survey of the production of iron and steel. For a detailed study of the subject the reader is referred to the vast number of books available on the subject. An attempt is made in the following pages to give the story of the transformation of iron ore into Pig Iron, Cast Iron, Steel etc. in a way that an average welder will understand it.

IRON ORE

Iron ore exists in Nature all over the world in the following forms:

1. Hematite
2. Limonite
3. Magnetite
4. Siderite
5. Pyrite

In India, Hematite occurs in very large quantities (approximately 3,000 million tons) in the districts of Manbhum (Bihar), Mayurbanji, Bonai and Keonjhar (Orissa), as also in Mysore. The principal Iron and Steel Companies in India Messrs. Tata Iron & Steel Co., Ltd., The Indian Iron & Steel Co., Ltd. and The Mysore Iron & Steel Co., Ltd. use this type of ore for the production of iron and steel.

The Iron content of Hematite is 70% theoretically, but as much as approximately 60% of iron is obtained from this type of ore by the Iron and Steel Processing Companies in India.

The Principal Raw Materials required by the Iron and Steel Industry are:

1. Good quality Iron Ore
2. Fuel (Cocking Coal)
3. Flux (Lime Stone or Dolomite)
4. Refractory materials (Fire-clay, Quartz Magnesite, etc.)

As far as the Ore is concerned, India is fortunate in having the biggest and high grade deposit which can be mined here at a cost lower than any other part in the world.

India's Cocking Coal deposits do not enjoy the same abundance and quality as Iron Ore. Owing to their larger ash content, more coke is used per ton of ore

smelted. An idea of the coke requirements of a Blast Furnace is given below :

To produce one ton of Pig Iron, the required quantities of Coke and Iron Ore are as follows :

1 Ton of coke (from 1.1/3 ton of coking coal)

1½ Tons of Iron Ore.

FLUX

The position of Fluxes, i. e., Lime stone and Dolomite is the same as that of Coking Coal; the quality of these materials is not very good, but moderately good fluxing materials being available near the processing plants at very cheap rates, the cost element of fluxing materials in the Pig Iron produced is not higher than any other parts of the world.

With regard to the Refractory materials, no difficulty is experienced and sufficient production of quality Fire Bricks is carried on in Ranigunj, near Calcutta, which is close to the steel processing plants.

With the availability of these Raw Materials in abundance, India is able to produce Pig Iron cheaper than any manufacturer in the World, and has registered herself as an exporter of Pig Iron to Japan etc.

PRODUCTION OF PIG IRON

From the raw materials described above Pig Iron is produced from the Iron Ore in what is called a Blast Furnace. The charge containing the correct proportions of the raw materials is lowered into the stack by means of cup and Cone.

In the Blast Furnace, the coke is ignited at the bottom and it burns under forced draft. As it burns away, ore and lime stone are converted into liquid iron and slag. The materials move downwards by gravity and the stack is kept filled by fresh charges admitted through the cone device already mentioned.

The process of heating inside the blast furnace is aided by the admission, through the tuyers, of hot air pre-heated in stoves to approximately 700 degrees Centigrade. The slag which floats at the top of the molten metal in the crucible is tapped at a higher level, and is either thrown off or utilised in various other ways.

The hot gases from the furnace are not wasted. A part is led into a battery or stoves, usually four per Blast Furnace and burnt there to heat the incoming air from the Blowing Machine, the capacity of which is roughly 1,00,000 C. ft. of air per minute.

The surplus gases from the furnace is utilised in the following ways:

25% for heating the blast

15% for driving the Blowing Engine

60% for generation of power and other uses

Where a blast furnace is in operation, large quantities of water are required for:

1. Cooling Furnace parts subjected to intense heat
2. For feeding the Boilers
3. For cleaning the furnace gas before they are let into the stoves.

Summarising the requirements of a blast furnace, we require :

1. A Blast furnace
2. Hauling mechanism for charging the furnace
3. Air Compressors Blowers to produce the blast
4. Stoves for heating the blast
5. Facilities for pumping large quantities of water
6. Power generating plant.

The first stage of producing pig iron from iron ore having been discussed, we now proceed to the production of cast iron and steel.

CAST IRON

Cast Iron and Steel (which latter is described later) form the major portion of the metals that present themselves to the welder, and it is imperative that the welder and those connected with welding understand

the characteristics of these two categories of iron and steel.

Cast Iron is obtained by the melting of pig iron and scrap iron together with a small quantity of fluxing materials. The melting is done in a Cupola. The Process is roughly as follows:

The bottom portion of the fire-brick lined Cupola is first charged with coke up to about 1/3rd over a layer of wood and other cumbustible materials about 10 to 12″ from the bottom. This charge of coke is called the Bed Coke. The bed coke is then lit from the bottom opening of the cupola and the coke is allowed to burn by natural draught. This goes on for about 2 to 3 hours when the pig iron and the coke and scrap iron are charged into the cupolo in alternate layers. At this time the Blowing machine is started and air is let into the cupola by means of tuyers located around the cupola. This inlet of air increases the temperature inside the cupola and the melting takes place (usually within 15 minutes from the time the charge is made and air let in) until liquid iron is formed at the bottom of the cupola. This is tapped off at intervals and carried in clay and mud lined buckets to the moulds. At intervals the slag which floats on the molten metals is also removed through an opening which is at a higher level than that for the tapping of the metal.

In the moulds the molten pig iron transforms itself into various forms of cast iron articles. The place where the cupola functions and casting takes place is called the Foundry.

Some times the pig iron is melted in a crucible but the crucible casting is invariably limited to non-ferrous casting, such as brass, aluminium etc.

STEEL

Both Steel and Cast Iron belong to Iron-Carbon alloy group. The iron-carbon Steel is by far the most important of ferrous metals. The word ferrous is derived from the latin word "Ferrum" for iron as distinguished from the non-ferrous group, i. e., Copper and its alloys, Aluminium etc.

It is impossible to say what course our civilization would have taken if steel were not discovered. Without steel there would not have been the great ocean liners, Railway tracks, locomotives, Automobiles, modern steel structured buildings and various other implements on which humanity depends. In fact, the progress of the world would have been negligible without the members of the Iron and Steel family. It is therefore right to say that Iron and Steel are the life of the humanity and part of it.

It would be advantageous at this juncture to deal briefly with the characteristics of various categories of iron and steel.

WROUGHT IRON

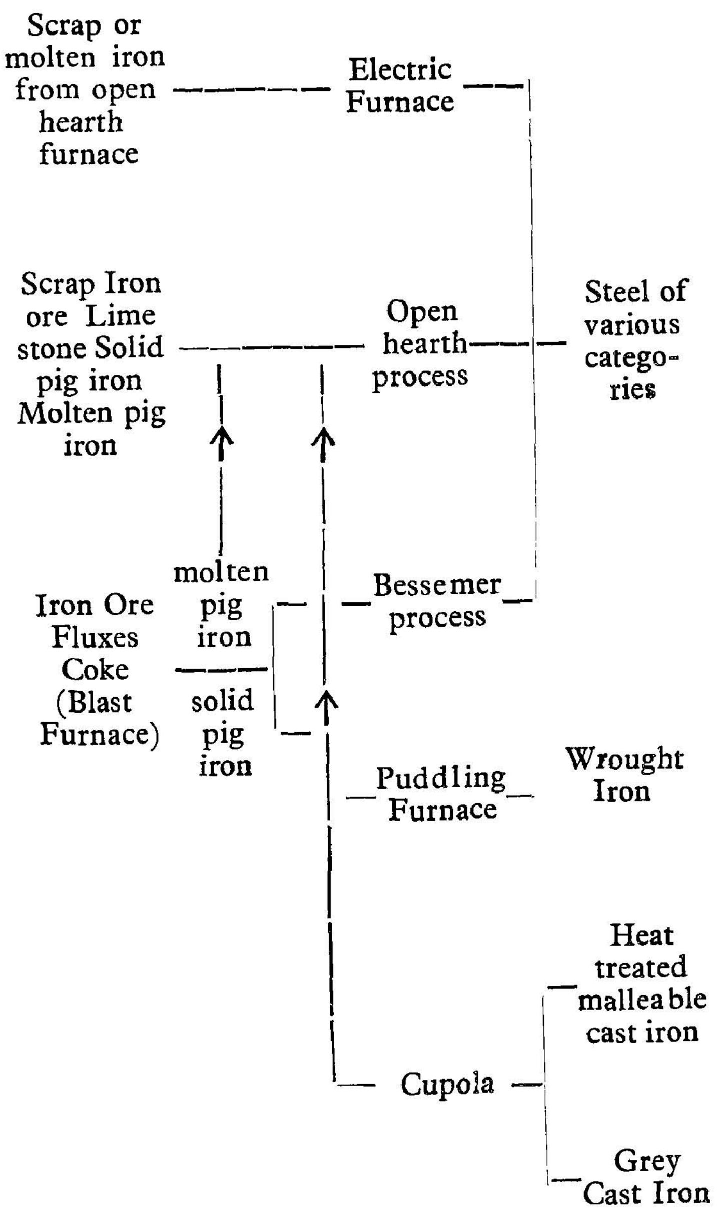
Wrought Iron is a ferrous metal composed of almost pure iron and iron silicate commonly known as slag. Wrought iron is made in a Puddling Furnace from Pig Iron and, but for the slag inclusion, is very similar to pure iron. This is the purest form of iron available. Some examples of the uses of wrought iron are: Crane hooks, bolts, water pipes etc. Owing to the slag inclusion it is resistant to corrosion, oxidation or rusting.

A normal specification of wrought iron would be:

C	.. 0.04
P	.. 0.09
S	.. 0.02
Mn	.. 0.05
Si	.. 0.08
Slag	.. 1.5

In some specimens, however, the slag content is as much as 3%. The slag content in wrought iron is evenly distributed in the form of threads along the line of rolling.

An important point to be remembered with wrought iron is the fact that wrought iron melts at a higher temperature than most of the ferrous metals. With other ferrous metals, suitable for welding, the welding temperature is indicated by the fluxed or greasy surface. With Wrought Iron, however, this indication only shows that the fluxing action of the slag content is taking place, and this temperature being below the fusion temperature of the base metal, welding at this temperature should not be proceeded with. Heating should be continued till the fusion of the base metal is achieved.



Schematic Representation of the manufacture Cast Iron and Steel

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Diagram showing the various Iron-Carbon alloys and Examples of their uses

CAST IRON & STEEL

As already pointed out, both Cast Iron and Steel are members of the Iron-Carbon alloy group and the percentage of carbon in any given alloy determines whether it is steel or cast iron. The following table gives the percentages of carbon present in the different Iron-Carbon alloys :

Type of Iron-Carbon Alloy	*Percentage of Carbon*
Wrought Iron	.. 0.04
Mild Steel	.. 0.25
Medium Carbon steel	.. 0.25 to 0.45
High Carbon steel	.. 0.45 to 1.5
Cast Iron	.. 2.5 to 4.5

Iron carbon alloys of 1.5 to 2.5 carbon content are not in wide use, and it will be seen from the above table that Iron-Carbon alloys with carbon contents ranging from 2.5, place themselves within the category of Cast Iron. As a matter of fact, the dividing limit between steel and cast iron has been recognised as 1.7% carbon.

ROLL OF CARBON IN IRON-CARBON ALLOYS

Here it will be advantageous to enter into a brief discussion of the role of carbon in iron-carbon alloys. It has already been pointed out that iron 100% purity, not being available, wrought iron should be considered as a close second. The addition of the alloying element carbon in these alloys increases the hardness and strength of the alloy up to a certain limit, which can be taken as 1% carbon content. Between 1 & 1.5% Carbon content, the alloy tends to increase in hardness but diminishes somewhat in strength. As will be seen from the table given above, up to this limit, i. e., 1.5%, the alloy is classified as high carbon steel, the use of which is limited to tools and other instruments which are required to be very hard.

Iron carbon alloys with a carbon content of 2.5% and over are classified as cast iron, the qualities of which are :

1. Good castability
2. Moderate strength and hardness
3. Low Ductility

The Engineering Industry, however, uses low and medium carbon steel to a very great extent. For different jobs, Iron carbon alloys of various carbon contents are selected. A diagram showing the alloys with different carbon contents and examples of their uses, appears on page 11.

The melting points of the various categories of iron-carbon alloys are given below :

	Category of Iron-carbon alloy	*Melting point*
1.	Pure Iron	.. 1530 deg. C.
2.	Cast Iron	.. 1235 „
3.	Malleable Iron	.. 1235 „
4.	Wrought Iron	.. 1593 „
5.	Hard Steel (.4/.7%C)	.. 1371 „
6.	Low Carbon Mild Steel	.. 1482 „
7.	Man. Steel	.. 1343 „
8.	3½% Ni. Steel	.. 1427 „
9.	Cast Steel	.. 1343 „
10.	Stainless Steel	.. 1490 „

The proceedure for the welding of each type of cast iron and steel is not discussed here, as this is being dealt with in the article to be continued.

ALLOY STEELS

Various alloying elements are added to steel in addition to carbon, to achieve various properties and these are discussed here briefly.

MANGANESE

Ordinarily, steels containing about 0.4% manganese and steels with 1% manganese are extremely hard and wear resisting. Steels of manganese content between 1% and 7% are extremely brittle, and there is no way of removing this brittleness, but when the quantity of Manganese is increased to the region of 12 to 14%, we get a manganese steel which when heated to near melting point and rapidly quenched, will give a material possessing the ductility of steel and retaining all the hardness of the material not subjected to heat treatment. Manganese steel is selected for jobs where extreme hardness is required such as rock crushing equipment, Railway crossings etc.

STAINLESS STEEL

This is an alloy of steel containing about 18% Chromium and 8% Nickel, and the rest iron, and is generally known as 18/8 Stainless steel. Stainless steels have been classed into the following different groups:

Stainless iron

An alloy of chromium and nickel and iron or chromium of iron with a carbon content of 0.15%.

Ferritic stainless steel

This is a stainless iron containing about 18% chrome and a low carbon content.

Martensitic Stainless Steel

In this alloy the principal alloying element is chromium only, used for cutting knives, surgical instruments, etc. and is very resistant to corrosion.

Austenitic Stainless steel

This is the usual stainless steel of the 18/8 variety (staybrite etc.) very resistant to corrosion and is used for chemical food, and industrial equipment. To prevent weld decay after welding, heat treatment up to 950 deg. C. to 1150 deg. C. is recommended.

TUNGSTEN STEEL

This alloy usually contains 5 to 15% Tungsten and up to 1.8% carbon. The alloying element of Tungsten renders the metal self-hardening. This is used for high speed metal cutting tools.

VANADIUM STEEL

This is an alloy containing .2 to .25% Vanadium, the properties of which are, increase in tensile strength and elasticity. The Vanadium in the alloy also acts as a fatigue resistent. Examples of uses are Springs, Axles and parts subjected to vibration and high stresses.

MOLYBDENUM STEEL

This is very similar to Tungsten steel, but contains .15% to .25% Molybdenum which tends to increase the hardness and endurance limits of the steel. It also increases the corrosion resistant quality in stainless steels. Examples of uses are, crank shafts of motor cars etc.

NICKEL STEEL

When Nickel is added as an alloying element, it gives the metal strength, toughness and resistance to abrasion. These alloys usually contain 4% Nickel and .45% carbon. The alloys are very suitable for heat treatment, examples of uses are Armour Plates, Rails etc.

Injurious Effects of certain elements present in steel

PHOSPHORUS

The occurrence of this element in steel makes it brittle. It is generally present in percentages of .03 to .04. The Phosphorus content makes the metal liable to cracks when cold worked, and is supposed to produce what is called " Cold Shortness ".

SULPHUR

Unlike phosphorus, sulphur produces " hot shortness ", i. e., liability to crack when hot. The safe percentage limit is the same as for phosphorus.

Before going to non-ferrous metallurgy, we will briefly describe the different process of steel manufacture.

Production of steel by Bessemer Converter

This process consists of the oxidation of the impurities of molten pig iron through the agency of cold air blown under a high pressure in small steam through a shallow bath of molten iron contained in a vessel called the converter. This converter has been provided with holes at the bottom for letting in air.

The molten pig iron is transferred to this converter after tilting the converter into a horizontal position, so that the molten metal may not run into the tuyers at the bottom. The blast of cold air at the rate of 30,000 Cu.ft. per minute at 30/35 lbs. per sq. in. pressure is let in. The converter can now be brought into its original vertical position, the powerful blast keeping the molten metal from running down the tuyers. The blast is continued for about ten minutes, by which time almost all the impurities are eliminated by oxidation. The converter is again brought into the horizontal position and the steel tapped off after recarburising the same to the extent required.

The process of conversion in a Bessemer Converter results in the metal being deprived of its carbon contents beyond the desired limit and the process of recarburising by the addition of carbon in the form of coke is very necessary. Side by side with this recarburisation, some deoxidising elements are also added in the shape of ferro-manganese, ferro-silicon, aluminium etc. with the result that the remaining gases in the metal are eliminated. The finished steel of the proper composition is then cast into ingots, then reheated and rolled into the required shapes.

Production of Steel by the open hearth process

This process of producting steel differs from the Bessemer Converter process in that the de-carburising of the molten pig iron is achieved by the addition of iron ore. The process also uses the sensible heat of the outgoing products of combustion to preheat the fuel and the incoming air, thus obtaining the very high temperature required in steel making. In a Bessemer converter the heat of the bath is maintained by the purifying and decarburising reactions going on, but in an open hearth process, external heat is supplied, as also the incoming air and the fuel are preheated.

In the basic open hearth process, the charge of the furnace consists of:

1. Solid and Liquid pig iron
2. Scrap
3. Iron Ore
4. Lime Stone

and the order of the charge is:

1. Plate scrap or if this is not available, then Lime stone
2. Iron Ore
3. Scrap
4. Solid pig iron
5. Molten pig iron from mixers obtained from Blast Furnace

The charge consisting of the first four items, takes about 2 to 3 hours to become molten, and at this stage, molten pig iron is added.

It is found some times that the carbon is being eliminated too fast, i.e., even before phosphorus is eliminated, so that sufficient quantity of pig iron is added, whereas if the carbon is being eliminated at a lower rate, iron ore is added. When the process of decarburising is complete, the metal is tapped.

After tapping, recarburising and deoxidising elements are added in the ladle, as this process cannot be achieved in the furnace.

When alloy steels are desired, the necessary alloying elements are also added in the ladle, where the elements are easily oxidised. In the case of alloying elements which are not easily deoxidised, these are added in furnace towards the end of the heat. The comparative features of the Bessemer and open hearth processes are given below:

1. The process starts from the stage of molten pig iron obtained from the blast furnace.	1. The process is a complete one starting from the ore stage, although scrap, solid pig iron and molten pig iron are added during the process.

2. The heat of the bath is maintained by the purification or decarburising process going on in the bath.	2. The charge of ore, scrap and solid pig is heated by an independent outside source, i.e., fuel gas, assisted by hot air. The fuel is also preheated by the sensible heat of the outgoing furnace gases.
3. The composition of the pig iron should have a high P/content for the reaction to yield the required temperature to be maintained in the converter. In this case P is not entirely eliminated, which results in a low quality steel.	3. The process of purification in the bath being slow, better quality steel results.
	4. In the open hearth process the pig iron phosphorus may be in the region of one 1% only and its elimination is therefore more complete than the Bessemer steel.

Manufacture of Steel by the Electric Furnace

The Electric furnace, using Electricity as the source of heat to melt the charge, is used for:

1. Producing steel from steel scrap or molten metal from the open hearth.

2. For super refining of steel obtained in the open hearth process.

Here, the furnace, is charged with scrap steel and an arc is struck between the charge and a set of carbon of graphite electrodes, which are manually operated in the initial stages and switched on to automatic control after the arc has become steady.

During the process, ore, Mills Scale and lime are added as oxidising elements. The carbon and Phosphorus contents are deoxidised and slag is formed on top. After this, slag is removed and lime coke dust and flour spar are added to make a second slag which is called the Carbide Slag. When this slag has been formed and taken to a stage where it yields Acetylene when contacted with water, it is to be assumed that the molten bath has been completely deoxidised as also desulphurised.

At this stage, the additions consisting of ferr-silicon and other alloying elements are added gradually without unduly affecting the temperature of the bath. The steel is then tapped.

By whatever method the steel is produced, it is ultimately poured into ingot moulds and such ingots devoid of any defects are then hot worked into various items of bars, rounds, flats etc.

GREATER EMPHASIS ON STAFF WELFARE IN RAILWAYS CULTIVATING INDIVIDUAL GOODWILL FOR PLAN'S SUCCESS

A new orientation is to be given to the Railway personnel organisations throughout the country, with greater emphasis on staff welfare measures as distinguished from mere establishment matters.

This re-orientation of approach to the staff has been decided upon by the Railway Board in the belief that during the Second Five Year Plan period the best possible results from individual members of the Railway staff can be obtained only by winning their personal goodwill.

In a directive issued to the various Railway Administrations, the Railway Board has suggested the allotment of a whole-time officer for personnel work in each Railway district, which is the smallest unit of Railway administration.

In the selection of personnel officers, the Railways have been advised to pick only persons who have a flair for this type of work, a thorough knowledge of rules and regulations, and a sympathetic nature. These officers should be asked to tour frequently and, as far as possible, to settle staff grievances on the spot, with warm human interest in the welfare of the individuals who approach them for assistance or advice.

The Railway Board's directive is based on certain recommendations made by the Railway Corruption Enquiry Committee.

Brush Bagnall Diesel Electric Locomotives

GENERAL DESCRIPTION

THE locomotive is of the type designated AIA—AIA, the superstructure being mounted on two bogies, each bogie having three axles of which the two outer axles are motored whilst the centre axle is for carrying purposes only.

The locomotive superstructure has a driving cab at each end mounted behind a short, streamlined, nose end compartment. The power unit with its auxiliary equipment and control gear is mounted in the main body of locomotive. A partition separates the engine from the generator and control equipment, and unobstructed walk-ways are provided on both sides of the power unit.

Both driving cabs are fitted with a driver's position and controls on the left-hand side of the cab with an assistant driver's position on the right-hand side of the cab. All instruments essential to the driver are mounted on a panel in front of the driver and his assistant. Unobstructed vision for both men is provided by large driving windows, fitted with pneumatically operated windscreen wipers. A powerful headlamp is fitted into the nose at each end of the locomotive.

Immediately behind No. 1 cab is the main radiator ducting carrying the radiator fan motor and runner. Air is drawn through the radiator panels, which are mounted vertically on either side of the locomotive, and after passing through the twin branches of the ducting is ejected upwards through a grille in the roof.

Access to the main body of the locomotive is provided by doors in the cab bulkheads. At No. 1 end, the centre walk-way through the radiator ducting branches on either side of the diesel engine; the generous loading gauge of the Ceylon Railways allowing sufficient space between engine and locomotive sides for the withdrawal of the engine pistons and connecting rods from the sides of the crankcase.

Doors are provided in the partition separating the engine and generator compartments and the walk-ways continue on either side of the main and auxiliary generators, exhausters, compressor and controls equipment cubicle. Doors in No. 2 cab bulkhead give access into No. 2 driving cab.

The nose and compartments in front of each driving cab contain a traction motor blower, electrically driven, which supplies filtered air to the two traction motors in the bogie beneath. Access to the nose compartment is by removable panels inside the cab and by hinged louvre panels on the outside of the locomotive nose.

All auxiliaries are electrically driven with the exception of the engine cooling water circulating pump, which is belt driven from the free end of the crankshaft, and the engine lubricating oil pumps, which are gear driven from the crankshaft. Power for the auxiliary machines is taken from the auxiliary generator, which is mounted on an extension of the main generator shaft.

The main fuel tank and batteries are slung beneath the locomotive between the bogies. A separate fuel service tank is mounted in the roof of the locomotive.

Due to the bad weather conditions encountered in Ceylon, which include tropical rain and heavily corrosive salt atmosphere, special care has been taken to make all ventilating and air inlet louvres water-proof and anti-corrosive materials have been used throughout the construction of the locomotive.

DIESEL ENGINE

The locomotive is powered by a Mirrlee, Bickerton and Day, Vee-type 12 cylinder, turbo-charged four-stoke oil engine, with a rating of 1,254 B. H. P. at 850 r. p. m. under normal temperature and altitude conditions.

Under site conditions in Ceylon, the engine develops 1,000 H. P. at 850 r. p. m.

The bedplate is of welded construction, and carries the crankshaft bearings. The cylinder housing and upper part of the crankcase are also of fabricated construction and the complete crankcase assembly is solidly bolted to the bedplate. The cylinders themselves are of the "wet" type.

The crankshaft is of solid forged steel and is supported by main bearings of steel, white metal lined. The pistons are of light alloy fitted with compression and scraper rings. The piston pins are of the floating type. The connecting rods are of steel "H" section and carry marine type large end bearings consisting of steel-backed white metal shells.

The twin camshafts are mounted in the cylinder housing and are driven by spur gears from the flywheel end of the crankshaft. They are located on the outer sides of the two banks of cylinders, and operate the valve and fuel pumps through roller ended push rods and tappers.

The engine is force-lubricated from gear type lubricating oil pumps, and a shutdown device is incorporated which automatically stops the engine when the oil pressure falls below a certain point, or when the engine speed exceeds a certain limit.

The engine cooling water is circulated by a water pump, belt-driven from the forward end of the crankshaft.

The engine and generator, which are bolted together to form a single unit, are mounted on three pedestals carrying Silentbloc bushes, thus eliminating any possible distortion of the locomotive underframe being transmitted to the diesel engine.

ENGINE AUXILIARIES

The engine is started by motoring the main generator from starting batteries slung beneath the underframe. Starting connections cannot be made until sufficient oil pressure has been built up in the diesel engine by an electrically driven priming pump.

Fuel oil is delivered to the engine fuel rail under pressure by an electrically driven fuel transfer pump. In the event of failure of this pump, fuel is supplied from a service tank under gravity feed. A semi-rotary fuel transfer pump is provided for filling the service tank from the main fuel tank.

Suitable radiators are supplied for the diesel engine oil and water cooling circuits.

The radiator fan which draws air through the radiators and expels it through the roof, is driven by an electric motor fed from the auxiliary generator.

ELECTRICAL EQUIPMENT

The main generator is directly coupled to the diesel engine and provides power to the four traction motors, which are axle hung on the outer axles of the two bogies. The motors may be connected in series-parallel, full-parallel or arranged so that an initial connection in series-parallel is re-grouped automatically to full-parallel.

Control of the locomotive is effected by varying the excitation of the main generator and the speed of the diesel engine. Current for the field excitation of the main generator, auxiliary machines, battery charging and operation of the control equipment is supplied from the auxiliary generator which is overhung from the main generator.

The main control cubicle is mounted in the generator compartment and is provided with doors giving full access to all equipment mounted in the cubicle. The cubicle is dust-proof, and special care has been given to the design of the control equipment to make it suitable for the arduous conditions of railway working.

The locomotives are arranged for multiple unit operation by which means two locomotives are coupled electrically as well as mechanically and operated together by a driver in the leading locomotive.

A single handle on the Master Controller enables the driver to select Engine Starting, Forward and Reverse positions and all running notches.

Lead acid batteries of 192 ampere-hour capacity are provided for starting the main power unit and for supplying the necessary auxiliary power when the diesel engine is not running.

The driving axles are fitted with tubes for the axle suspension of the traction motors, the nose of each traction motor being suspended by a flexible link from the centre transom.

The traction motors are fitted with roller bearings for both the armature and suspension bearings. The drive from the motors to the axles is taken through single reduction gearing; a pinion on the armature shaft meshing with a resilient gear wheel on the road axle.

BRAKE EQUIPMENT

The locomotive is fitted with twin Westinghouse reciprocating exhausters, electrically driven, to provide vacuum for the train brakes. The locomotive itself is braked by compressed air brakes, four brake cylinders being fitted to each bogie and operating clasp brakes on all wheels. A Westinghouse compressor provides compressed air for the locomotive brakes, and also for the control and other auxiliary equipment.

The driver's brake controls consist of a vacuum brake valve which operates the train brakes and automatically operates the locomotive brakes through a proportional valve. This valve ensures that the locomotive air braking is applied in direct proportion to the vacuum braking on the train. A separate brake valve is supplied which gives independent braking on the locomotive when required.

A hand brake for the locomotive is also provided in each driving cab.

CONSTRUCTIONAL DETAILS

Underframe

The underframe is constructed of four main rolled steel "I" sections, which are reduced in depth over the bogies by means of flame cutting and welding along the neutral axis, in order to provide clearance for the bogies between underframe and rail head.

The two outer main members terminate at the bogie centre cross members, to which they are welded, but the inner main longitudinals continue and are welded integral with the fabricated drag box.

Cross members, which are riveted to the main longitudinals at various points along the underframe, carry channel section sole-bars and an unbroken deck of steel plate covers the underframe skeleton.

SUPERSTRUCTURE

The superstructure is constructed in sections comprising the two cab ends, two sides, and three roof sections.

All the superstructure is constructed of 14 gauge steel sheet welded to frameworks of angle and top hat section.

Entrance doors to the locomotive are provided on each side of both driving cabs. Top hatches in the roof section permit easy access to the cylinder heads of the diesel engine, and the roof itself is easily removable for major overhauls or complete removal of the power unit.

Port-hole type windows are provided in the sides of the engine and generator compartments, and full drop windows are provided in the cab doors and side windows.

BOGIES

The bogies are constructed from box type side frames of welded construction joined by a heavy fabricated steel centre transom, and by two channel members as headstocks.

The weight of the locomotive is carried on the centre bolsters of the bogies. Each bolster rests on eight nests of coil springs carried on two spring planks, one on each side of the centre carrier axle of each bogie. The spring planks in turn are suspended by swing links from the bogie side frames.

The leaf springs for the axles are carried internally in the hollow side frames, suitable openings being provided for inspection and withdrawal, whilst the coil springs are situated below the bogie frames.

Roller bearing axle boxes are fitted in manganese steel horn guides, which are replaceable.

Electro-pneumatic sanding gear, operated from a foot pedal in the driving cabs, is provided for the outer axles of each bogie.

LOCOMOTIVE DETAILS

Locomotive Weight	87 tons
Track Gauge	5′ 6″
Maximum Height	13′ 3½″
Maximum Width	10′ 3⅞″
Length over Buffers	50′ 9″
Bogie Wheel Base	10′ 6″
Bogie Centres	27′ 0″
Minimum Curve Negotiable	5 chains
Clearance from Gearcase to Rail Head	4½″
Capacity of Fuel Tank—main	775 gallons
—service	75 gallons
Wheel diameter—motored	3′ 7″
—carrier	3′ 0″

LOCOMOTIVE PERFORMANCE

Maximum speed	55 m.p.h.
Starting Tractive Effort (26% Adhesion)	33,700 lbs.
Tractive Effort (1 hour rating)	30,000 lbs. at 9.2 m.p.h.
Tractive Effort (continuous)	24,600 lbs. at 11.7 m.p.h.
Estimated Range with Full Fuel Tanks	750 miles

DIESEL ENGINE DETAILS

Maker	Mirrlees, Bickerton & Day
Type	JS12VT
Output at Sea level and normal temperature and Humidity conditions	1,254 H.P. at 850 r.p.m.
Developed continuous Power at Site	1,000 H.P. at 850 r.p.m.
Bore	$9\frac{3}{4}''$
Stroke	$10\frac{1}{2}''$
Number of Cylinders	12
Superchargers	Two, Napier type TS200/1
Exhaust Temperature (Cylinder outlet full load)	750°F./850°F.
Lubricating oil pressure	30 lbs./sq. inch

ELECTRICAL EQUIPMENT DETAILS

Main Generator	Brush Electrical Engineering Co. Ltd.
Continuous Rating	850 r.p.m. 652 kW. 630 V. 1,035A. 850 r.p.m. 652 kW. 750 V. 870A.
Auxiliary Generator	Brush Electrical Engineering Co. Ltd.
Continuous Rating	850 r.p.m. 35 kW., 110 V. 318A.
Traction Motors	Brush Electrical Engineering Co. Ltd.
Number per Locomotive	4
Continuous Rating	196 H.P. 315 V. 517.5A
1 Hour Rating	225 H.P. 315 V. 610A.
Gear Ratio	82 : 16
Radiator Fan Motor	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110V.3.1 H.P./12.6 H.P. 32/115A. 600/960 r.p.m.
Traction Motor Blower Motors	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110 V. 5 H. P. 1980 r.p.m.
Exhauster Motors	Brush Electrical Engineering Co. Ltd.
Continuous Rating	110 V. 3/6.05 H.P. 29/55A. 600/1,115 r.p.m.
Compressor Motor	Westinghouse Brake & Signal Co. Ltd.

AUXILIARY EQUIPMENT DETAILS

Compressor	Westinghouse Brake & Signal Co. Ltd.
Working Pressure	85/100 lbs./sq. inch
Exhausters	Westinghouse Brake & Signal Co. Ltd.
Type	4-cylinder reciprocating (4V 110)
Normal Speed	600 r.p.m
" Release " speed	1,115 r.p.m.
Batteries	D.P. Battery Co. Ltd.
Number of Cells	48
Capacity	192 amp.-hours @ 5-hour rate
Traction Motor Blower	Sturtevant
Output	2,940 cu. ft. per min. 2,170 r.p.m.
Radiators	Serck Radiators Limited
Axle Box Bearings	The Skefko Ball Bearing Co. Ltd.

HANDING OVER CEREMONY OF WAGONS AT OKHA

At a simple ceremony at Okha, Mr. Sherman Cooper, United States Ambassador handed over the first lot of 40 Metre Gauge wagons to India on Wednesday, 4th January, 1956. The ceremony was held in a shamiana near the Wagon Assembly Plant at Okha. Among the distinguished guests at the turnover ceremony, were Shri Naik Nimbalker, Minister for Public Works, Bombay Government, Mr. Clifford Wilson, Director of the U. S. Technical Co-operation Mission in India and Shri K. P. Mushran, Member (Staff), Railway Board.

These wagons are out of a lot of 8,730 wagons (4365 Broad Gauge and 4365 Metre Gauge) being made available to India under the Indo-American Technical Cooperation Programme by the United States of America and are being manufactured by the American Car and Foundary Company of New York. The wagons will be assembled at the Railway Assembly Plant at Okha.

Shri O. V. Alagesan, Deputy Minister for Railways accepting the wagons on behalf of the Railway Ministry thanked the Ambassadar for the help extended by the United States Government for the rehabilitation and development of India's premier transportation system.

Mr. Sherman Cooper, speaking on the occasion stated that the United States were glad to have been associated with India in the first years of its great venture in economic development. Continuing, the U. S. Ambassador stated " There is nothing new about American aid to India, just as there is nothing new about American friendship for India. In the days of your freedom struggle, the United States urged Indian independence. Since then the United States had demonstrated its interest that India should succeed in establishing economic independence. There is no doubt that India will succeed, and in your great purposes my country gives its friendship and support. The role of my country has been small in comparison to the great effort of the Indian people and that is as it should be, for it is your country. "

Shri M. Ganapati, General Manager, Western Railway, thanked Mr. Sherman Cooper and the U. S. Government for their timely help and the U. S. people for this aid.

PASSENGER AMENITIES

In regard to amenities for passengers, the Railways have a record during the past few years of which any public utility undertaking might be proud. The standard of amenities has gone up noticeably in the Third class and the passenger who now travels third can do so with a sense of dignity and satisfaction that he no longer belongs to the " forgotten class ". It is true that over-crowding in trains persists on certain sections. Elimination of over crowding depends on several factors like availability of line capacity, locomotives and coaches. Getting all these is a slow process and according to the present indications, we may have to put up with the discomforts of over-crowding even during the Second Plan period. We have, however, tried to make travel more pleasant in other directions. The introduction of new integral all-steel coaches, has brought in the Third class travel a degree of comfort which can compare very favourably with the lowest class of travel anywhere in the world.

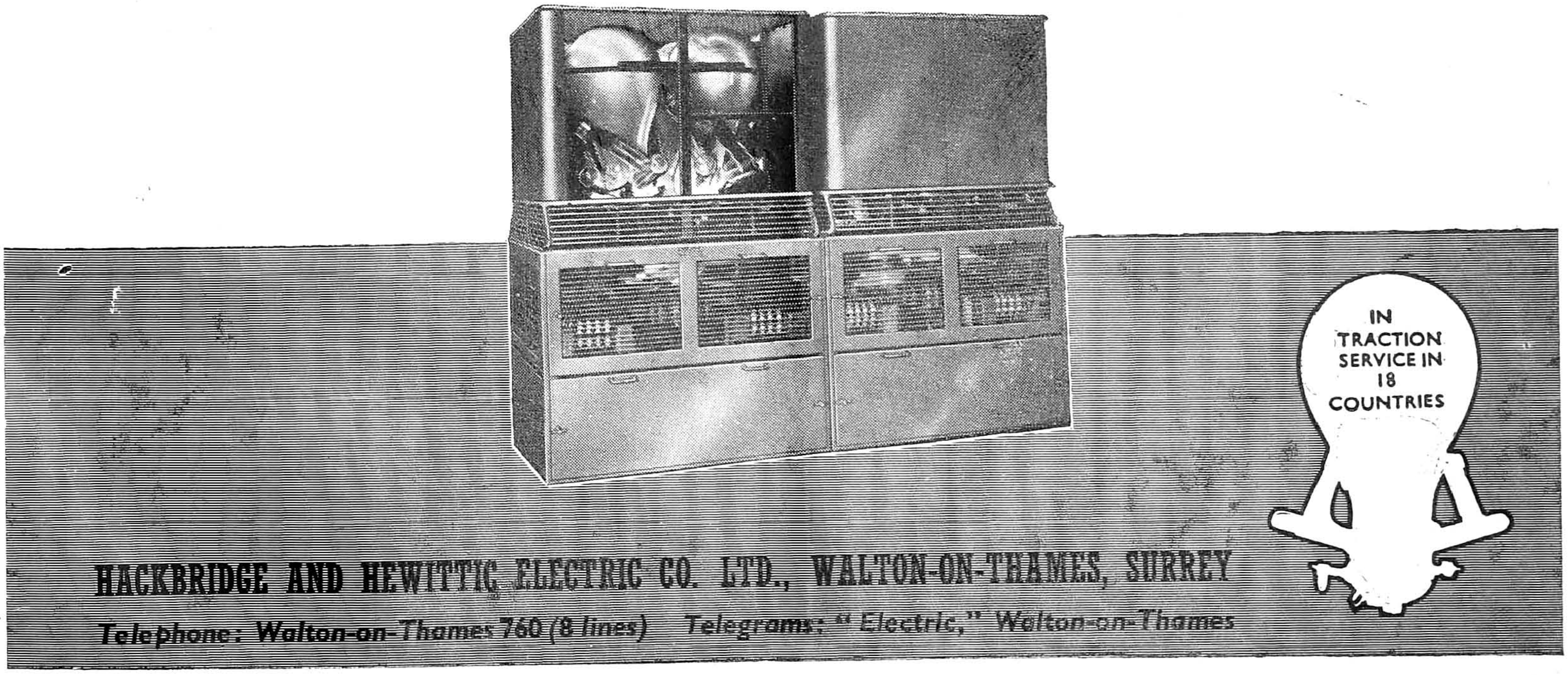
Sleeping berths for Third class passengers seemed a few years ago, something in the realm of dreamworld Introduction of this amenity in November, 1954, has indeed been a revolutionary step.

We are watching the experiment of all-Third class corridor train, which was initiated between Delhi and Howrah last October. It has also been decided to run a fast and fully Air-Conditioned corridor train from next October for First and Third class passengers.

ON THE RIGHT LINES

Electrification schemes in which HEWITTIC RECTIFIERS are specified as the converting plant are on the right lines—lines which stretch back over a past experience of 30 days in the manufacture of heavy duty rectifiers and which lead on to long, reliable and economical service.

Over 1½ million kilowatts of Hewittic Rectifiers are in world-wide operation in installations of up to 8,750 kw capacity.



Agents:

India: Steam and Mining Equipment (India) Ltd., 101 Park Street, Calcutta, Post Box 405.
Easun Engineering Co., Ltd., 5-7 Second Line Beach, Post Box 95, Madras-1.

Pakistan: James Finlay & Co., Ltd., P. O. Box No. 29, Finlay House, Karachi.

CLEANLINESS LEADS TO HEALTH AND HAPPINESS

Clean orderly habits contribute to general health and welfare and as such to happiness and prosperity; they are more important than medicines.

Cleanliness prevents disease; medicine only attempts to cure.

Cleanliness of the person, of the houses and colonies, reflects discipline in the individual and the community. Discipline is the foundation stone for progress of oneself and the country. Cleanliness is a good habit. It is also cheap.

All Railwaymen should set an example of cleanliness. This will help others and themselves.

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